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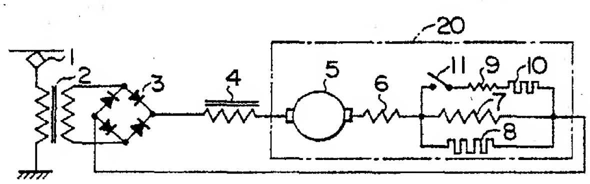
(54) **D.C. motor for a vehicle.**

(57) A D.C. motor for a vehicle driven by a pulsating current has an inductive shunt (9) connected in parallel with a main pole winding (7) of the motor (20). The inductive shunt has an inductance which is larger than 20% of an inductance of the main pole winding so that a spark in the rectification operation is suppressed.



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D.C. MOTOR FOR A VEHICLE

The present invention relates to a D.C. motor for rolling, and more particularly to a D.C. series motor for rolling stocks suitable for a pulsating current operation.

A D.C. motor can be operated by either D.C. or pulsating current depending on a type and a quality of a power supply which feeds to the D.C. motor and a physical dimension of a filtering reactor mounted on rolling stocks. In a prior art D.C. motor for the vehicle, when it is operated by the pulsating current, a sparking voltage E_s is generated due to a vector difference between a reactance voltage E_r of the motor (a voltage between brushes of the D.C. motor) and a velocity e.m.f. E_ϕ generated by interpole magnetic fluxes. Means for compensating resultant sparking voltage E_{sp} (3V) of the arc voltage E_s and a transformer e.m.f. E_t of a main pole has not been proposed. As a result, a commutation performance of the pulsating current driven motor for the rolling stocks has been low due to the resultant sparking voltage E_{sp}.

It is an object of the present invention to provide a D.C. motor for a vehicle operated by a pulsating current having an inductive shunt connected in parallel to a main pole winding, which inductive shunt having an inductance larger than 20% of an

inductance of the main pole winding, in order to improve a commutation performance in the pulsating current operation.

Other objects, features and advantages of the present invention will be apparent from the following detailed description of the invention with reference to the accompanying drawings, in which:

Fig. 1 shows a circuit configuration of a pulsating current motor to which the present invention is applicable;

FIg. 2 shows a waveform illustrating a phase relationship between an armature current and an interpole magnetic flux of the pulsating current motor shown in Fig. 1;

Fig. 3 shows a vector diagram illustrating a relation among a reactance voltage, a velocity e.m.f. by the interpole magnetic flux and a sparking voltage of the pulsating current motor;

Fig. 4 shows a vector diagram illustrating a relation among the reactance voltage, the velocity e.m.f. and the sparking voltage when a transformer e.m.f. is taken into consideration;

Fig. 5 shows an equivalent circuit of a main pole under a field-weakening control;

Fig. 6 shows a vector diagram illustrating a relation among the arc voltage, the transformer e.m.f. and a resultant sparking voltage when an inductance of an inductive shunt is varied; and

Fig. 7 shows a relation between the inductance of the inductive shunt and the commutation spark numbers measured under the field-weakening control of the vehicle motor.

One embodiment of the present invention is now explained with reference to the drawings.

Fig. 1 shows an armature circuit of a pulsating current driven D.C. motor to which the present invention is applicable. A single phase A.C. power supply is supplied to a transformer 2 from a stringing through a pantagraph 1, and an output from the transformer 2 is supplied to a main motor 20 through a rectifier (e.g. a diode bridge rectifier) 3 and a filtering reactor 4. A main pole 7 has a pure resistor 8 connected in parallel thereto to minimize a pulsating current component flowing through the main pole 7 so that a field current is shunted by the pure resistor 8.

An inductive shunt 9 and a field-weakening resistor 10 are selectively inserted by a switch 11 to effect a field-weakening control (high speed control). The inductive shunt 9 not only contributes to the field-weakening control but also contributes to improve a rectification performance in the pulsating current driven D.C. motor.

Fig. 2 shows current waveforms of currents flowing through an armature 5 and an interpole 6. A pulsating factor μ is generally expressed by

$$\mu = \frac{1}{2}\cdot\frac{I_{max} - I_{min}}{I_{max} + I_{min}} \times 100\ (\%) \ \ldots\ldots\ldots \ (1)$$

The pulsating factor is 50% - 25% at most in a present technology. When the pulsating current flows through the interpole circuit in the pulsating current operation, an eddy current flows through a magnetic circuit of the interpole because it includes a portion not completely laminated such as a magnetic frame so that an interpole magnetic flux ϕ is retarded by β_i with respect to a current I and an amplitude thereof is reduced as shown in Fig. 2. Accordingly, the commutation performance is lowered than when the motor is D.C. driven.

Fig. 3 illustrates a relation thereof. When the vehicle motor is D.C. driven, the commutation performance is high because a reactance voltage E_r and a velocity e.m.f. $E_{\phi DC}$ generated by the interpole magnetic flux are equal. However, when the rolling stocks motor is pulsating current driven, the velocity e.m.f. $E_{\phi DC}$ is changed to E_{ϕ} by the eddy current and a phase thereof is shifted by β_i relative to the reactance voltage E_r and an amplitude thereof is reduced. As a result, the reactance voltage E_r and the velocity e.m.f. $E\phi$ generated by the interpole magnetic flux in the pulsating current operation do not cancell each other and a sparking voltage E_s remains. This is one of the factors which lower the commutation performance in the pulsating current operation.

Another factor to lower the rectification performance is the transformer e.m.f. of the main pole. This is described below.

Fig. 4 shows a vector diagram illustrating a relation among the reactance voltage E_r, the velocity e.m.f. $E_{\phi DC}$ and the sparking voltage E_s when the transformer e.m.f. E_t is taken into consideration. Since the main pole 7 has the field shunting resistor 8 to reduce the pulsating current component, the pulsating current component in the mainpole 7 is smaller than the pulsating current component in the interpole 6 and the armature 5 and a phase thereof is retarded by γ. A phase of the transformer e.m.f. E_t is retarded by $(\gamma + \beta_f - 90°)$ relative to the velocity e.m.f. $E_{\phi DC}$, where β_f is a phase difference between the mainpole magnetic flux and the main pole current. The commutation performance in the pulsating current operation is lowered because the resultant sparking voltage E_{sp} of the transformer e.m.f. E_t and the sparking voltage E_s is not compensated. In Fig. 4, I_f denotes the pulsating current component of the main pole current and ϕ_f denotes the pulsating component of the main pole magnetic flux.

The commutation performance in the pulsating current operation is not seriously lowered to compare with the D.C. operation in a full field operation (low speed operation) but it is lowered in the field-weakening control (high speed operation). Therefore,

only the field-weakening control is considered here.

The reactance voltage E_r, the velocity e.m.f. E_ϕ by the interpole magnetic flux and the sparking voltage E_s are constant for a given motor and cannot be changed. On the other hand, the magnitude and the phase of the transformer e.m.f. E_t can be changed by appropriately selecting the inductance of the inductive shunt.

Fig. 5 shows an equivalent circuit of the main pole under the field-weakening control. The current i_f in the main pole is given by

$$i_f = i \cdot \frac{R_s(r_i+jX_i)}{R_s(r_i+jX_i)+R_s(jX_f+r_f)+(jX_i+r_i)(jX_f+r_f)} \quad \cdots \quad (2)$$

where i is a current in the interpole and the armature, X_i is the inductance of the inductive shunt, r_i is the field-weakening resistance, X_f and r_f are an inductive component and a resistive component of the mainpole winding and R_s is a field shunt resistance. Fig. 6 shows a vector diagram of the sparking voltage E_s, the transformer e.m.f. E_t and the resultant sparking voltage E_{sp} when X_i is increased in the formula (2). As seen from Fig. 6, as the magnitude and the phase of the transformer e.m.f. E_t are increased, the magnitude of the resultant sparking voltage E_{sp} is reduced so that the commutation performance is improved.

Fig. 7 shows a relation between the inductance of the inductive shunt and the rectification spark

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numbers (resultant sparking voltage E_{sp}) measured under the field-weakening control of the vehicle motor. The spark numbers include 1 to 8, in which 1 indicates a non-sparking condition and 8 indicates a highest sparking condition. As seen from Fig. 7, as the inductance of the inductive shunt is increased, the commutation performance is remarkably improved.

Assuming that the practically acceptable spark numbers are 3 to 8, the inductance of larger than 2 mH is sufficient. The inductance of the main pole under this condition is approximately 10 mH. By providing the inductive shunt having the inductance which is larger than 20% of the inductance of the main pole winding, the commutation performance in the pulsating current operation of the vehicle motor can be substantially improved.

As described hereinabove, according to the present invention, the inductive shunt having the inductance which is larger than 20% of the inductance of the main pole winding is connected in parallel with the main pole winding. Accordingly, the vehicle motor having an improved commutation performance in the pulsating current operation is provided.

WHAT IS CLAIMED IS:

1. A motor for a vehicle driven by a pulsating current, characterized by

an inductive shunt (9) connected in parallel with a main pole winding (7),

said inductive shunt having an inductance larger than 20% of an inductance of said main pole winding.

2. A D.C. series motor for a vehicle characterized by

an armature (5);

an interpole winding (6) connected in series with said armature;

a main pole winding (7) connected in series with said interpole winding;

a resistive shunt (8) connected in parallel with said main pole winding for shunting a pulsating current flowing through said main pole winding when said motor is operated by a pulsating current; and

an inductive shunt circuit (9, 10, 11) connected in parallel with said main pole winding,

said inductive shunt circuit having an inductive shunt (9) having an inductance larger than 20% of an inductance of said main pole winding, a field control resistor (16) connected in series with said inductive shunt and a mechanical switch (11) connected in series with said resistor.

3. In a combination of rolling stocks having a pantagraph (1) slidably engaging with a stringing

for supplying a single phase A.C. power, a single phase transformer (2) having a primary winding connected to said pantagraph, a full-wave rectifier (3) connected to a secondary winding of said transformer and a filtering reactor (4) connected to an output terminal of said rectifier for supplying a pulsating current; and a D.C. motor (20) driven by the pulsating current for driving said vehicle;

characterized by that said D.C. motor includes an inductive shunt (9) connected in parallel with a main pole winding thereof, said inductive shunt having an inductance larger than 20% of an inductance of said main pole winding.

FIG. 1

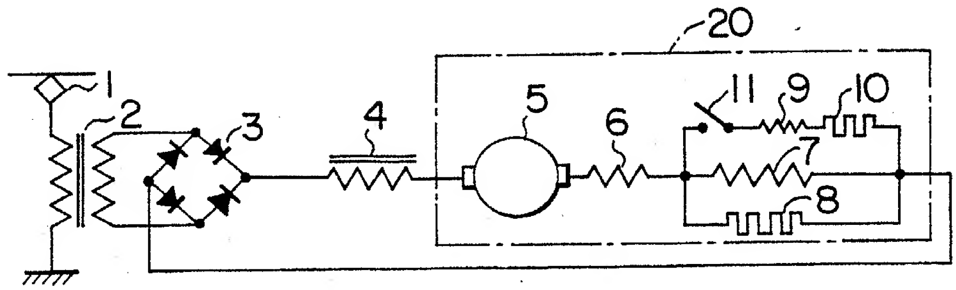


FIG. 2

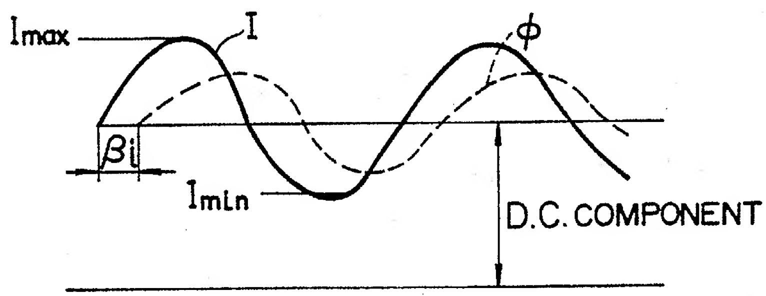


FIG. 3

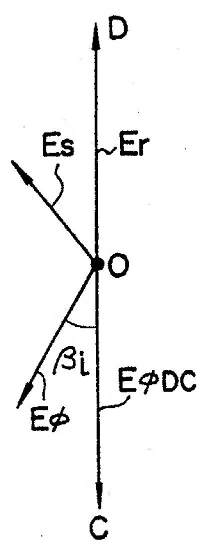


FIG. 4

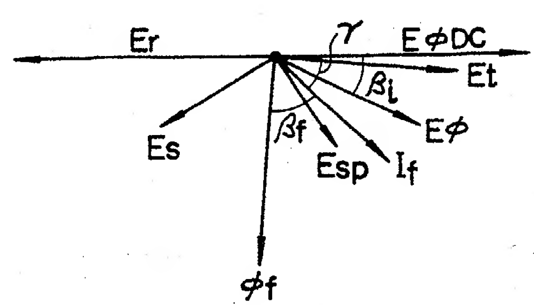


FIG. 5

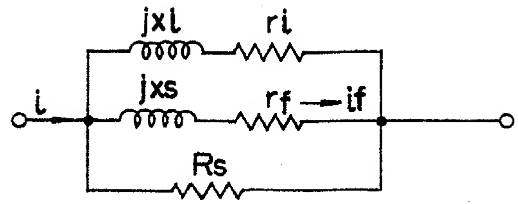


FIG. 6

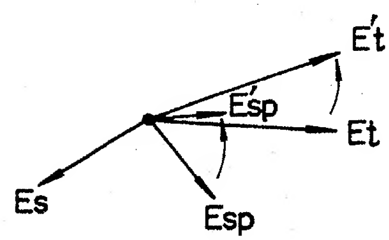
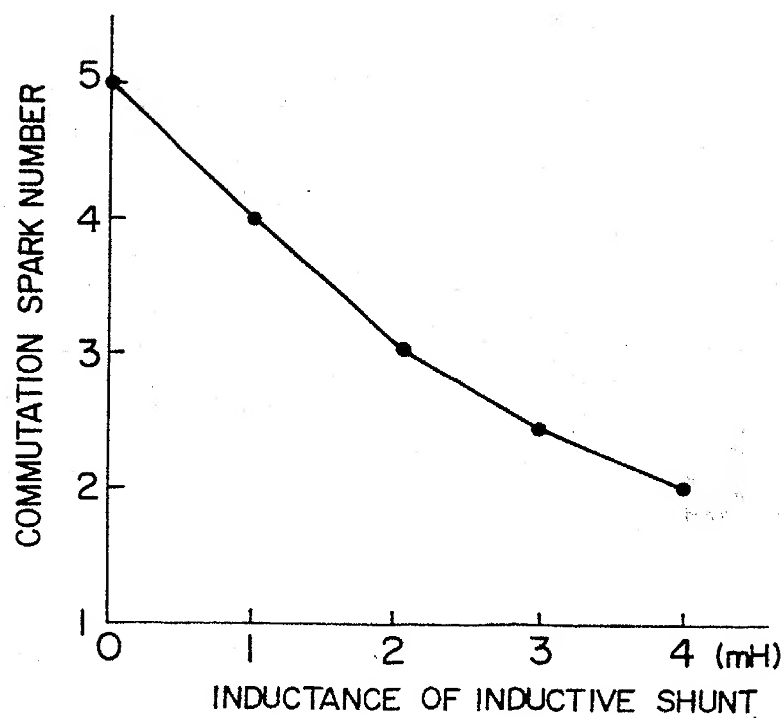


FIG. 7



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EUROPEAN SEARCH REPORT

0078417 Application number

EP 82 10 9429

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Y	DE-C- 596 466 (AEG) * Complete document *	1-3	H 02 K 23/02 B 60 L 9/12
Y	DE-C- 276 990 (BBC) * Claim 2 *	1-3	
Y	DE-C- 674 671 (SIEMENS-SCHUCKERTWERKE) * Page 1, lines 1-36; figure 26 *	1-3	
A	DE-B-1 157 257 (SIEMENS-SCHUCKERTWERKE) * Column 1, line 1 - column 3, line 3 *		
A	DE-C- 594 373 (SIEMENS-SCHUCKERTWERKE) * Complete document *		**TECHNICAL FIELDS SEARCHED (Int. Cl. 3)** B 60 L 9/00 H 02 K 23/00 H 02 P 7/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	13-01-1983	GESSNER E A F

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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